

OBJECT OF THE INVENTION

It is an object of a preferred embodiment of the invention to provide
apparatus for a heat pump and/or a heat pump which will increase the
5 utilization of available energy in such apparatus at present.

It is an alternative object of a preferred embodiment of the invention to
provide a method of controlling a heat pump which will increase the efficiency
of such apparatus at present.

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It is an alternative object of a preferred embodiment of the invention to
provide a method of controlling a turbine and generator which will increase the
efficiency of such apparatus at present.

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It is an further alternative object of a preferred embodiment of the
invention to provide a turbine and/or a method of communicating a fluid to a
turbine which will increase the utilization of available energy from such fluid at
present.

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It is a still further alternative object to at least provide the public with a
useful choice.

Other objects of the present invention may become apparent from the
following description, which is given by way of example only.

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SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a turbine
for generating power including:
a rotor chamber;
30 a rotor rotatable about a central axis within said rotor chamber;
at least one nozzle including a nozzle exit for supplying a fluid from a fluid
supply to said rotor to thereby drive said rotor and generate power;
at least one exhaust aperture to, in use, exhaust said fluid from said turbine;
wherein

the flow of said fluid from said at least one nozzle exit is periodically interrupted by at least one flow interrupter means, thereby raising the pressure of said fluid inside said at least one outer nozzle.

5 Preferably, the turbine includes at least one fluid storage means between said fluid supply and said at least one outer nozzle.

 Preferably, said at least one flow interrupter means substantially stops the flow of said fluid from said at least one nozzle exit until the pressure inside
10 said at least one nozzle rises to a preselected minimum pressure, which is less than or equal to the pressure of the fluid supply.

 Preferably, when the turbine is in use, said flow of said fluid from said at least one nozzle is interrupted by said at least one interrupter means for a
15 period sufficient to bring said fluid immediately upstream of said at least one outer nozzle substantially to rest.

 Preferably, said rotor has a plurality of channels shaped, positioned and dimensioned to provide a turning moment about said central axis when
20 refrigerant from said at least one nozzle enters said channels.

 Preferably, said rotor is has a plurality of blades shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle contacts said blades.
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 Preferably, said at least one flow interrupter means includes at least one vane connectable to and moveable with an outer periphery of said rotor and adapted to interrupt the flow of said fluid out of said at least one outer nozzle exit when said at least one vane is substantially adjacent said at least
30 one nozzle exit.

 Preferably, said flow interrupter means includes a plurality of said vanes substantially evenly spaced apart around said outer periphery of said rotor.
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Preferably, said turbine is included in a heat pump circuit, wherein said fluid supply is a positive displacement compressor.

5 Preferably, said fluid storage means has a capacity at least equal to a displacement of said positive displacement compressor.

10 Preferably, said at least one exhaust aperture includes diffuser and expander sections to decrease the velocity of said fluid and maintain the pressure of the fluid low once it has decelerated to a subsonic velocity.

Preferably, said at least one nozzle in use supplies said fluid to said rotor at a sonic or supersonic velocity.

15 According to a second aspect of the invention there is provided a method of communicating a fluid supplied by a fluid supply means at a fluid supply means pressure to a turbine rotor, the method including; providing at least one nozzle for communicating said fluid from said fluid supply means to said turbine rotor, to thereby drive said rotor, the method further including providing at least one flow interrupter means to periodically interrupt the flow of said fluid out of said at least one nozzle, thereby raising the pressure of said fluid inside said at least one nozzle to a preselected minimum pressure which is less or equal to said fluid supply means pressure before resuming the flow of said fluid out of said at least one nozzle.

20 Preferably, said preselected minimum pressure is sufficient to cause the fluid to reach the local sonic velocity at a throat of the nozzle.

25 Preferably, the method includes accelerating fluid exiting said at least one nozzle to supersonic velocities.

30 According to a third aspect of the present invention, there is provided a turbine including a rotor including two or more spaced apart rotor windings and a stator including a plurality of stator windings about said rotor, wherein at least two of said stator windings are connected to a controllable current

source, each controllable current source operable to energise the stator windings to which it is connected.

5 Preferably, each controllable current source is operable to energise the stator windings to which it is connected after the rotor has reached a predetermined velocity.

10 Preferably, the predetermined velocity is the terminal velocity for the current operating conditions of the turbine.

Preferably, each current source increases or decreases the current through their respective stator windings dependent on a measure of the power output from the stator windings.

15 According to a fourth aspect of the invention, there is provided a method of controlling a turbine including a rotor including two or more spaced apart rotor windings and a stator including a plurality of stator windings about said rotor, wherein at least two of said stator windings are connected to a controllable current source, each controllable current source operable to
20 energise the stator windings to which it is connected, the method including repeatedly measuring the power output from the stator windings and increasing the current through the windings if the current measure of power output is greater than a previous measure of power output and decreasing the current through the windings if the current measure of power output is less
25 than a previous measure of power output.

According to a fifth aspect of the invention, there is provided a thermodynamic cycle including a compressor, a first turbine downstream of the compressor, a heat exchanger located downstream of the first turbine and
30 operable to reject heat from the cycle to another thermodynamic cycle, an evaporator downstream of the heat exchanger and a second turbine downstream of the evaporator and upstream of the compressor.

According to a sixth aspect of the invention, there is provided a
35 thermodynamic cycle including a compressor, a condenser downstream of the

compressor, a first turbine downstream of the condenser, an evaporator downstream of the first turbine and a second turbine downstream of the evaporator and upstream of the compressor.

5 Preferably, the thermodynamic cycle further includes a heat exchanger located between said first turbine and said evaporator, the heat exchanger operable to reject heat to another thermodynamic cycle.

10 Preferably, the first and second turbines are turbines according to the preceding paragraphs.

The thermodynamic cycle of any one of claims 21 to 24, wherein the first and second turbines are turbines according to the preceding paragraphs.

15 According to a seventh aspect of the invention, there is provided a control system for a thermodynamic cycle including a compressor, the control system including:
sensing means for providing a measure of an output of the thermodynamic cycle;
20 control means for the compressor, wherein the control means is in communication with said sensing means to receive as inputs said measure of an output of the thermodynamic cycle and a measure of the work input of the compressor;
wherein the control means is operable to compute a measure of efficiency
25 from said inputs and vary the speed of the compressor to maximise said measure of efficiency or to maintain said measure of efficiency at a predetermined level.

30 Preferably, the control system further includes second control means for a TX valve or equivalent and sensing means for providing a measure of the temperature of a controlled area, wherein the second control means receives as a further input said measure of the temperature of a controlled area, and is operable to open or close the TX valve or equivalent in response to sensed variations in temperature in the controlled area in relation to a
35 target measure.

Preferably, the second control means further receives as an input a measure indicative of the amount of refrigerant in the cycle which is vaporised after an evaporation phase in the cycle and to open or close the TX valve or equivalent to maintain vaporised refrigerant after the evaporation phase.

Preferably, the operation of the second control means to maintain vaporised refrigerant after the evaporation phase is performed after a predetermined delay from the control means opening or closing the TX valve in response to said sensed variations of temperature.

Preferably, the control system further includes third control means for a condenser in the thermodynamic cycle, the control system varying the operation of the condenser to maintain a required level of cooling of refrigerant by the condenser.

Preferably, the control system is operable to control a turbine according to claim 17 and including fourth control means to control the direct current through the stator windings of said turbine.

Preferably, the control system is operable to control the direct current through the stator windings to dynamically maintain the balance of said turbine when loaded.

Preferably, the control means, second control means, third control means and fourth control means is a single microcontroller or microprocessor or a plurality of microcontrollers or microprocessors with at least selected microcontrollers or microprocessors in communication with each other to allow management of the timing of the functions of the control system.

According to an eighth aspect of the invention, there is provided a method of controlling a turbine including a rotor including two or more spaced apart rotor windings and a stator including a plurality of stator windings about said rotor, wherein at least two of said stator windings are connected to a controllable current source, each controllable current source operable to

energise the stator windings to which it is connected, the method including adjusting the current through the windings in order to dynamically maintain the balance of said rotor.

5 Further aspects of the present invention, which should be considered in all its novel aspects, will become apparent from the following description, given by way of example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

- 10 Figure 1: Shows a prior art thermodynamic cycle.
- Figure 2: Shows a first thermodynamic cycle according to an aspect of the present invention.
- 15 Figure 3: Shows a second thermodynamic cycle according to an aspect of the present invention.
- Figure 4: Shows a cross-sectional view of a first turbine according to an aspect of the present invention.
- 20 Figure 5: Shows a cross-sectional view of a second turbine according to an aspect of the present invention.
- Figure 6: Shows an enlarged view of a channel of the turbine of Figure 5.
- Figure 7: Shows a third thermodynamic cycle illustrating a control system according to an aspect of the present invention.
- 30 Figures 8 – 10, 12: Show flow charts of a method of controlling a thermodynamic cycle according to aspects of the present invention.
- Figure 11: Shows a diagram of a generator according to an aspect of the present invention.
- 35 Figure 13: Shows a flow chart of an initialisation subroutine for the control system.
- 40 Figure 14: Shows a flow chart of a scheduling subroutine for the control system.

CLAIMS

1. A turbine for generating power including:
 - a rotor chamber;
 - 5 a rotor rotatable about a central axis within said rotor chamber;
 - at least one nozzle including a nozzle exit for supplying a fluid from a fluid supply to said rotor to thereby drive said rotor and generate power;
 - at least one exhaust aperture to, in use, exhaust said fluid from said turbine;
 - 10 wherein
 - the flow of said fluid from said at least one nozzle exit is periodically interrupted by at least one flow interrupter means, thereby raising the pressure of said fluid inside said at least one outer nozzle.
- 15 2. The turbine of claim 1 including at least one fluid storage means between said fluid supply and said at least one outer nozzle.
3. The turbine of claim 1 or claim 2, wherein said at least one flow interrupter means substantially stops the flow of said fluid from said at least one
20 nozzle exit until the pressure inside said at least one nozzle rises to a preselected minimum pressure, which is less than or equal to the pressure of the fluid supply.
4. The turbine of any one of claims 1 to 3, wherein in use, said flow of said
25 fluid from said at least one nozzle is interrupted by said at least one interrupter means for a period sufficient to bring said fluid immediately upstream of said at least one outer nozzle substantially to rest.
5. The turbine of any one of claims 1 to 4, wherein said rotor has a plurality
30 of channels shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle enters said channels.

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6. The turbine of any one of claims 1 to 4, wherein said rotor is has a plurality of blades shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle contacts said blades.
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7. The turbine of any one of claims 1 to 6, wherein said at least one flow interrupter means includes at least one vane connectable to and moveable with an outer periphery of said rotor and adapted to interrupt the flow of said fluid out of said at least one outer nozzle exit when said at least one vane is substantially adjacent said at least one nozzle exit.
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8. The turbine of claim 7, wherein said flow interrupter means includes a plurality of said vanes substantially evenly spaced apart around said outer periphery of said rotor.
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9. The turbine of any one of claims 1 to 8, when included in a heat pump circuit, wherein said fluid supply is a positive displacement compressor.
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10. The turbine of claim 9 when dependent on claim 2, wherein said fluid storage means has a capacity at least equal to a displacement of said positive displacement compressor.
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11. The turbine of claim 9 or claim 10, wherein said at least one exhaust aperture includes diffuser and expander sections to decrease the velocity of said fluid and maintain the pressure of the fluid low once it has decelerated to a subsonic velocity.
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12. The turbine of any one of claims 9 to 11, wherein said at least one nozzle in use supplies said fluid to said rotor at a sonic or supersonic velocity.
13. A method of communicating a fluid supplied by a fluid supply means at a fluid supply means pressure to a turbine rotor, the method including; providing at least one nozzle for communicating said fluid from said fluid supply means to said turbine rotor, to thereby drive said rotor, the method further including providing at least one flow interrupter means to

periodically interrupt the flow of said fluid out of said at least one nozzle;
thereby raising the pressure of said fluid inside said at least one nozzle to
a preselected minimum pressure which is less or equal to said fluid supply
means pressure before resuming the flow of said fluid out of said at least
one nozzle.

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14. The method of claim 13, wherein said preselected minimum pressure is
sufficient to cause the fluid to reach the local sonic velocity at a throat of
the nozzle.

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15. The method of claim 14, including accelerating fluid exiting said at least
one nozzle to supersonic velocities.

16. A turbine including a rotor including two or more spaced apart rotor
windings and a stator including a plurality of stator windings about said
rotor, wherein at least two of said stator windings are connected to a
controllable current source, each controllable current source operable to
energise the stator windings to which it is connected.

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17. The turbine of claim 16, wherein each controllable current source is
operable to energise the stator windings to which it is connected after the
rotor has reached a predetermined velocity.

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18. The turbine of claim 17, wherein the predetermined velocity is the terminal
velocity for the current operating conditions of the turbine.

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19. The turbine of any one of claims 16 to 18, wherein each current source
increases or decreases the current through their respective stator
windings dependent on a measure of the power output from the stator
windings.

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20. A method of controlling a turbine including a rotor including two or more
spaced apart rotor windings and a stator including a plurality of stator
windings about said rotor, wherein at least two of said stator windings are
connected to a controllable current source, each controllable current

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source operable to energise the stator windings to which it is connected, the method including repeatedly measuring the power output from the stator windings and increasing the current through the windings if the current measure of power output is greater than a previous measure of power output and decreasing the current through the windings if the current measure of power output is less than a previous measure of power output.

21. A thermodynamic cycle including a compressor, a first turbine downstream of the compressor, a heat exchanger located downstream of the first turbine and operable to reject heat from the cycle to another thermodynamic cycle, an evaporator downstream of the heat exchanger and a second turbine downstream of the evaporator and upstream of the compressor.

22. A thermodynamic cycle including a compressor, a condenser downstream of the compressor, a first turbine downstream of the condenser, an evaporator downstream of the first turbine and a second turbine downstream of the evaporator and upstream of the compressor.

23. The thermodynamic cycle of claim 22 further including a heat exchanger located between said first turbine and said evaporator, the heat exchanger operable to reject heat to another thermodynamic cycle.

24. The thermodynamic cycle of any one of claims 21 to 23, wherein the first and second turbines are turbines according to any one of claims 1 to 11.

25. The thermodynamic cycle of any one of claims 21 to 24, wherein the first and second turbines are turbines according to any one of claims 17 to 20.

26. A control system for a thermodynamic cycle including a compressor, the control system including:
sensing means for providing a measure of an output of the thermodynamic cycle;
control means for the compressor, wherein the control means is in

communication with said sensing means to receive as inputs said
measure of an output of the thermodynamic cycle and a measure of the
work input of the compressor;
wherein the control means is operable to compute a measure of efficiency
from said inputs and vary the speed of the compressor to maximise said
measure of efficiency or to maintain said measure of efficiency at a
predetermined level.

27. The control system of claim 26, further including second control means for
a TX valve or equivalent and sensing means for providing a measure of
the temperature of a controlled area, wherein the second control means
receives as a further input said measure of the temperature of a controlled
area, and is operable to open or close the TX valve or equivalent in
response to sensed variations in temperature in the controlled area in
relation to a target measure.

28. The control system of claim 26 or claim 27, wherein the second control
means further receives as an input a measure indicative of the amount of
refrigerant in the cycle which is vaporised after an evaporation phase in
the cycle and to open or close the TX valve or equivalent to maintain
vaporised refrigerant after the evaporation phase.

29. The control system of any one of claims 26 to 28, wherein the operation of
the second control means to maintain vaporised refrigerant after the
evaporation phase is performed after a predetermined delay from the
control means opening or closing the TX valve in response to said sensed
variations of temperature.

30. The control system of any one of claims 26 to 29 including third control
means for a condenser in the thermodynamic cycle, the control system
varying the operation of the condenser to maintain a required level of
cooling of refrigerant by the condenser.

31. The control system of any one of claims 26 to 30, operable to control a
turbine according to claim 17 and including fourth control means to control

the direct current through the stator windings of said turbine.

32. The control system of claim 31, operable control the direct current through
the stator windings to dynamically maintain the balance of said turbine
5 when loaded.

33. The control system of claim 31, wherein the control means, second control
means, third control means and fourth control means is a single
microcontroller or microprocessor or a plurality of microcontrollers or
10 microprocessors with at least selected microcontrollers or
microprocessors in communication with each other to allow management
of the timing of the functions of the control system.

34. A method of controlling a turbine including a rotor including two or more
15 spaced apart rotor windings and a stator including a plurality of stator
windings about said rotor, wherein at least two of said stator windings are
connected to a controllable current source, each controllable current
source operable to energise the stator windings to which it is connected,
the method including adjusting the current through the windings in order to
20 dynamically maintain the balance of said rotor.